Day and Night Energy Spectra and Constraints on Neutrino Mixing Parameters[1]

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SNO has provided strong evidence that neutrinos change flavor as they propagate from the core of the Sun [2, 3], independently of solar model flux predictions. This flavor conversion can be explained by neutrino oscillation models based on flavor mixing. For some values of the mixing parameters, spectral distortions and a measurable dependence on solar zenith angle are expected. The latter might be caused by interaction with the matter of the Earth (the MSW effect) and would depend not only on oscillation parameters and neutrino energy, but also on the path length and e^- density through the Earth. This report presents SNO's first measurements of day and night neutrino energy spectra, and constraints on allowed neutrino mixing parameters.

The data reported here were recorded between November 2, 1999 and May 28, 2001. The total livetimes for day and night are 128.5 and 177.9 days, respectively. The data reduction in [3] was used here. For each event, the number, pattern, and timing of the hit PMTs were used to reconstruct effective recoil electron kinetic energy T_{eff}, radial position R, and scattering angle $\theta_\odot$ with respect to the Sun-Earth direction. The CC, ES and NC reactions each have characteristic probability density functions (pdfs) of T_{eff}, R, and $\theta_\odot$.

The measured night and day fluxes ϕ_N and ϕ_D were used to form the asymmetry ratio for each reaction: $\mathcal{A} = 2(\phi_N - \phi_D)/(\phi_N + \phi_D)$. The CC interaction is sensitive only to ν_e. The NC interaction is equally sensitive to all active neutrino flavors, so active-only neutrino models predict $\mathcal{A}_{NC} = 0$. The same models allow $\mathcal{A}_{CC} \neq 0$. The ES reaction has additional contributions from $\nu_{\mu\tau}$ leading to a reduction in its sensitivity to ν_e asymmetries.

There are 3 free parameters in the fit: the total ^{8}B flux Δm^2 , and the mixing angle θ. Contours were generated in Δm^2 and $\tan^2\theta$. Fig. 1(a) shows allowed mixing parameter regions using only SNO data with no additional experimental constraints or inputs from solar models. By including the Cl and Ga experiments, the day and night spectra from the SK experiment, along with solar model predictions for the more robust *pp*, *pep* and ^{7}Be neutrino fluxes, the contours shown in Fig. 1(b) were produced.

SNO has measured the day-night asymmetries of the CC, NC, and ES reaction rates. From these results the first direct measurements of the day-night asymmetries in the ν_e flux and the total ν flux from the Sun have been deduced. A global fit to SNO's day and night energy spectra and data from other solar neutrino experiments strongly favors the LMA and $\tan^2\theta$ values < 1 solution in a 2-flavor MSW neutrino oscillation analysis.

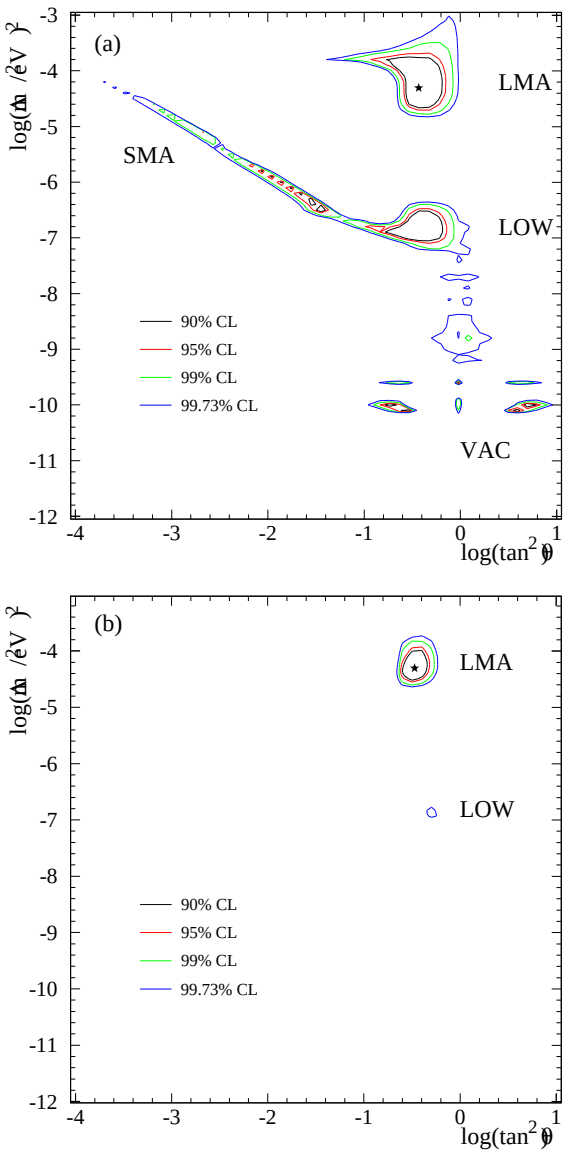

FIG. 1: Allowed regions of the MSW plane determined by a χ^2 fit to (a) SNO day and night energy spectra and (b) with additional experimental and solar model data. The star indicates the best fit.

[1] Condensed from Phys. Rev.LL **89**, 011302 (2002).
[2] Q.R. Ahmad *et al.*, Phys. Rev. Lett. **87**, 071301 (2001).
[3] Q.R. Ahmad *et al.*, Phys. Rev. Lett. **89**, 011301 (2002).